PETRIFIED PENNSYLVANIAN AGE PLANTS OF EASTERN OHIO[1]

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Abstract. The recent (1975) discovery of coal-ball petrifactions in the Duquesne and Ames coals of the Conemaugh Group provides an opportunity to make detailed studies of abundant and well preserved Pennsylvanian age fossil plants. Material from these beds was collected at a single location west of Steubenville, Ohio. Remains assignable to all the major groups of coal swamp plants were present, with the psaroniaceous tree ferns and medullosan seed ferns most abundantly represented. To date, 50 distinct taxa of plant remains have been discovered.

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Pennsylvanian age plants, preserved by calcareous cellular permineralization (coal balls), are among the most valuable of Paleozoic fossils. At localities where large quantities of material are available for study, features such as anatomical structure and plant habit can often be thoroughly examined (e.g. Dennis, 1974). In instances where preservation is especially good, developmental sequences and even reproductive mechanisms sometimes can be interpreted (e.g. Millay and Eggert, 1974). Unfortunately, known collecting localities of coal balls are few in number. In the Appalachian Basin only six discoveries have thus far been reported (Cross, 1967; Schopf, 1961); including two in Ohio (Good, personal communication; Good and Taylor, 1974). It is therefore of considerable importance that two new Ohio coal-ball localities are described.

LOCALITIES AND STRATIGRAPHY

Two coal seams were exposed in a road cut on the south side of Ohio Route 22 (NE ¼ SE ¼ SE ¼, Sec. 6, Wayne Township, Jefferson County), approximately five miles west of Steubenville, Ohio. Coal balls were present within both seams 1,000 m west of the highway bridge over Cross Creek. Separation of the seams by the Ames limestone (fig. 1) suggests that they are the product of

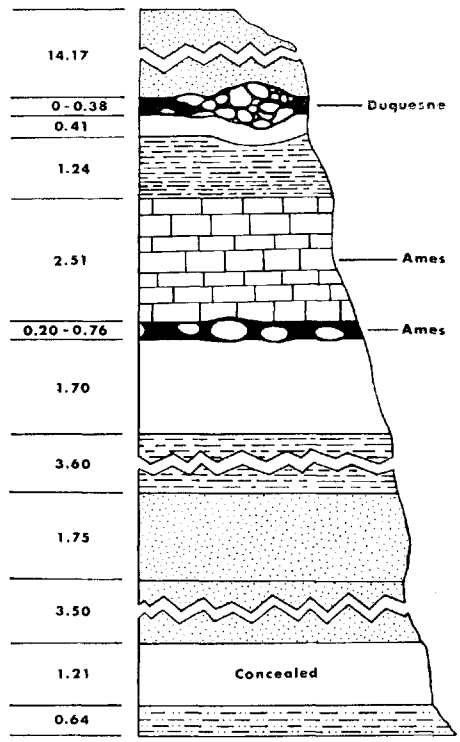

FIGURE 1. Stratigraphic column of collecting locality. Coals are black (with white coal balls). Clays are white and the remaining strata are indicated by standard lithologic symbols. Numbers at left indicate thickness of individual units in meters. Based on Ohio Division of Geological Survey section #13643.

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two separate depositional sequences, and therefore probably represent distinct floristic habitations of the area. The upper seam occurs approximately 1.5 m above the Ames limestone, from which it is separated by zones of clay and shale. This is the Duquesne coal (Duquesne Cyclothem), which is 0–38 cm thick at this exposure and in localized areas contains lenses of isolated or aggregated coal balls. In some areas coal from the bottom or top zone of the seam is replaced by coal-ball material and in other areas the seam consists primarily of coal balls separated by narrow coal stringers. In the latter areas the seam is expanded to as much as 1.3 m. The smaller coal balls are elipsoidal masses less than 3 cm in diameter and larger coal balls range to 1 m. Most of the material is light brown or beige in color with plants that are easily seen on weathered surfaces. Other coal balls are chocolate brown with more crushed plant remains. The surrounding calcareous matrix is usually a translucent white, but in places a gray limestone (probably marine in origin) replaces the other constituents.

The second coal seam lies directly below the Ames limestone (fig. 1) and is more difficult to identify. In Ohio, coal that occurs 0–7 m below the Ames limestone is of sporatic occurrence and has traditionally been regarded as the Harlem coal (e.g. Stout *et al*, 1923). In Athens County, the Harlem coal is separated from the Ames limestone by several meters of shale and sandstone, and by a coal seam that directly underlies the Ames limestone. This coal seam has been designated the Ames coal, and is considered to be equivalent to the Crinoidal or Friendsville coal of Maryland (Sturgeon, 1958). The lower coal seam of this report is therefore considered to be the Ames coal (Ames Cyclothem). This seam is 20–76 cm thick and contains isolated, dark brown, elipsoidal coal balls. They are round to oval, 15–70 cm in greatest length and typically contain crushed plant parts.

SYSTEMATIC DESCRIPTION

From approximately five hundred Duquesne coal balls, 46 genera and 50 species of fossil plants have been identified (table 1). The greatest volume of plant remains is assignable to the Psaroniaceae. Most of this consists of *Psaronius* free roots, but several stems also have been discovered. The specimen illustrated in

TABLE 1

Presently known flora of the Duquesne and Ames Coals

Plant	Duquesne Coal	Ames Coal
Alethopteris sp.	x*	x
Amyelon sp.	x	x
Anachoropteris involuta	x	x
Arthropitys sp.	x	x
Asterophyllites sp.	x	—
Biscalitheca musata	x	—
Botryopteris sp.	x	x
Bowmanites sp.	x	—
Calamocarpon sp.	x	—
Calamodendron sp.	x	—
Calamostachys sp.	x	—
Callistophyton poroxyloides	x	x
Callospermarion sp.	x	x
Cardiocarpus sp.	x	—
Cardiocarpus sp.	x	—
Conostoma cf. *platyspermum*	x	—
Conostoma cf. *quadratum*	x	x
Cordaianthus sp.	x	x
Cordaites sp.	x	x
Cyathotrachis sp.	x	x
Dolerotheca cf. *formosa*	x	—
cf. *Eoangiopteris* sp.	x	—
Etapteris sp.	x	x
Heterangium sp.	x	—
cf. *Hexapterospermum* sp.	x	—
cf. *Idanothekion* sp. (or *Callandrium* sp.)	x	—
cf. *Mazocarpon* sp.	x	—
Medullosa sp.	x	x
Mesoxylon sp.	x	x
cf. *Mitrospermum* sp.	x	—
Myeloxylon sp.	x	x
Neuropteris sp.	x	—
Pachytesta berryvillensis	x	x
Pachytesta cf. *hexangulata*	x	—
Pachytesta cf. *stewartii*	x	—
Paurodendron sp.	x	x
Pecopteris sp.	x	—
Psaronius chasei	x	(?)
Scolecopteris sp.	x	x
Sermaya sp.	x	—
Sigillaria sp.	x	x
Sigillariophyllum sp.	x	—
Sphenophyllum sp.	x	x
Stephanospermum sp.	x	—
Stigmaria sp.	x	x
Stipitopteris sp.	x	x
Tedelia sp.	x	—
Triletes	x	x
Tubicaulis sp.	x	—
Zygopteris berryvillenis	x	—

*x indicates presence of species.

figure 2 is assignable to *P. chasei* Morgan (1959). Frond segments (i.e., *Stipitopteris*) and the fertile pinnules of *Scolecopteris*, *Cyathotrachis*, and possibly *Eoangiopteris* are extremely abundant.

Of particular interest is the frequent occurrence of the coenopterid fern *Zygopteris berryvillensis* (fig. 6) Dennis (1974) and associated *Etapteris* foliar fragments. The zygopterid fructification *Biscalitheca musata* Mamay (1957) is also exceptionally well represented (fig. 5). Arborescent lycopsids appear to be entirely sigillarian in nature. These include branches assignable to *Sigillaria*, *Sigillariophyllum* leaves and *Stigmaria* rooting structures. Several large, lycopsid cone fragments, isolated megasporangia and microsporangia are frequently encountered. The articulates are represented by several taxa of vegetative and fertile organs assignable to the Calamitales and Sphenophyllales. These include *Arthropitys*, *Calamodendron* and *Sphenophyllum* (fig. 8) stems, and *Asterophyllites* and *Sphenophyllum* leaves. Sphenopsid cones have been identified as *Calamostachys*, *Calamocarpon* and *Bowmanites*. Gymnospermous remains are assignable to the Cordaitales and Pteridospermales. *Mesoxylon* stems, *Cordaites* leaves, *Amyelon* roots, *Cordaianthus* pollen strobili, and at least two species of the isolated ovule *Cardiocarpus* (fig. 10) were present in approximately 10% of the cut coal balls. Ovules tentatively assignable to *Mitrospermum* were also present. Among the pteridospermales, *Heterangium* stems and *Conostoma* ovules (fig. 4) are abundant. The Callistophytaceae is represented by *Callistophyton* stems and leaves, *Callospermarion* ovules and *Idanothekion* or *Callandrium* pollen organs (fig. 9). Medullosan pteridosperms were undoubtedly the most abundant seed plants. *Medullosa* stems, *Myeloxylon* petioles and *Neuropteris* pinnules of medullosan origin are extremely common. *Alethopteris* pinnules (fig. 7) of probable medullosan affinities are also represented. Ovules include at least three species of *Pachytesta* (fig. 3), *Stephanospermum*, and possibly *Hexapterospermum*.

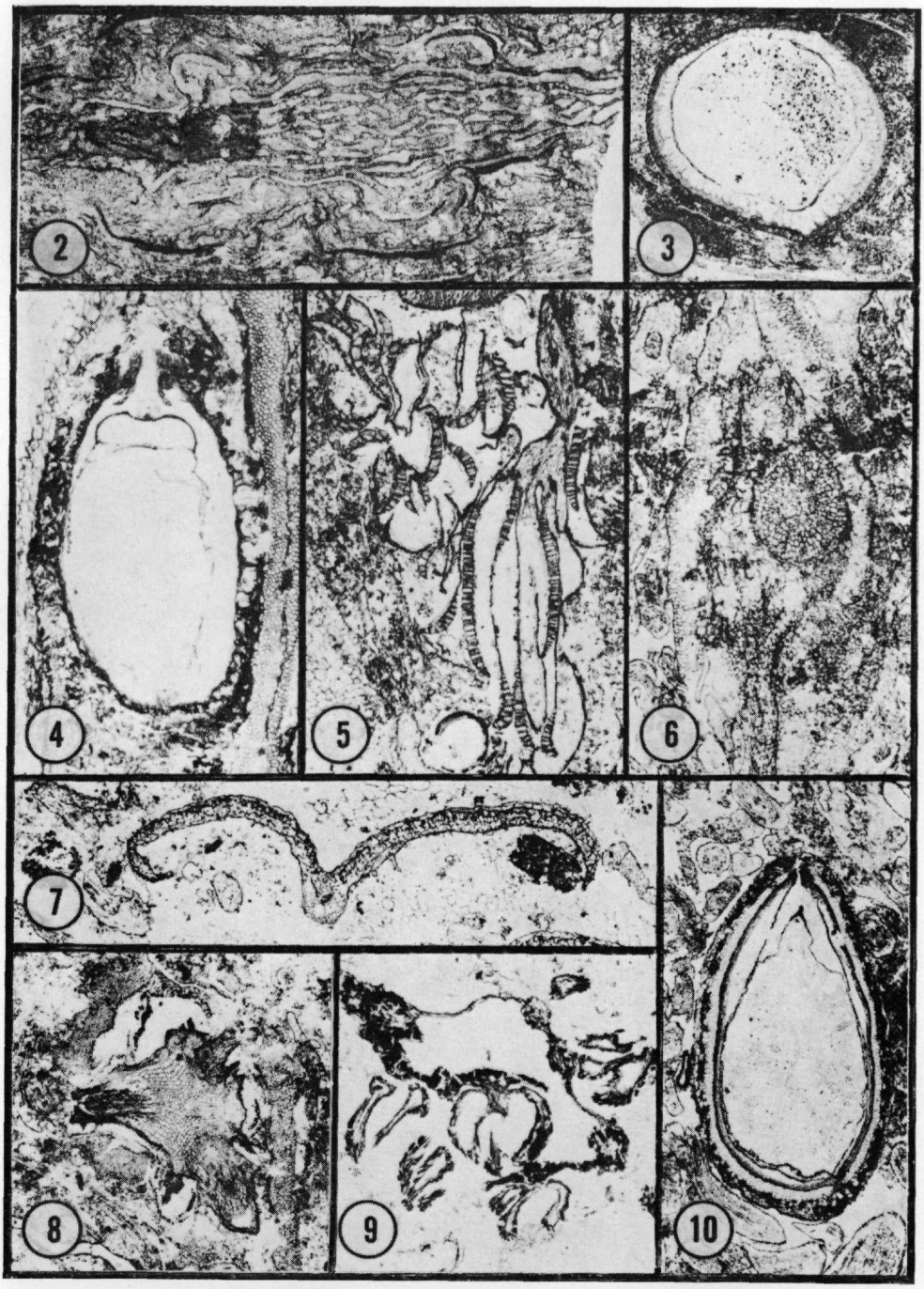
The number of available coal balls and quality of plant preservation in the Ames coal are below those described above. The Psaroniaceae is represented primarily by fragments of the bound root zone, with only a few crushed free roots present in most coal balls. Stems, foliar fragments and fertile material are also occasionally encountered. Remains of the Medullosaceae make up a large percentage of the flora. These include mostly crushed fragments of the outer "sclerenchymatous" cortex from stems and petioles, but some intact organs are also present. The Calamitales and Cordaitales are most abundantly represented by root material. Fertile structures of all groups occur with a lower frequency than in the Duquesne material.

DISCUSSION

Coal balls are now known from four stratigraphic levels in the Conemaugh and Monongahela Groups of Ohio. These include in ascending order the Anderson (?) coal (Good, C. W., personal communication), the Ames coal, The Duquesne coal and the Pittsburgh or Redstone coal

EXPLANATION OF FIGURES 2 TO 10

FIGURE 2. *Psaronius chasei* stem, somewhat flattened. O.U. coal ball 413 E Top. ×1.5.
FIGURE 3. *Pachytesta berryvillensis* ovule in oblique transverse section. O.U. coal ball 554 C Top. ×7.
FIGURE 4. *Conostoma* cf. *quadratum* in longitudinal section. O.U. coal ball 588 $E_{(1)}$ Top. ×25.
FIGURE 5. *Biscalitheca musata* sporangia in various planes of section. O.U. coal ball 407 A Bot. ×13.
FIGURE 6. *Zygopteris berryvillensis* stem in transverse section. O.U. coal ball 413 E Top. ×8.
FIGURE 7. *Alethopteris* sp. pinnule of medullosan affinities in transverse section. O.U. coal ball 613 D Bot. ×12.
FIGURE 8. *Sphenophyllum* sp. stem at nodal level showing the origin of three branches. O.U. coal ball 591 E Bot. ×5.
FIGURE 9. *Idanothekion* or *Callandrium* type pollen organs attached to *Callistophyton* foliage. O.U. coal ball 391 B Bot. ×26.
FIGURE 10. *Cardiocarpus* sp. ovule in oblique longitudinal section of the minor plane. O.U. coal ball 413 E Top. ×10.



FIGURES 2–10

(Good and Taylor, 1974). Of these, the flora of the Duquesne coal is the most extensive and well preserved. The amount of material available for collection is also far greater than currently known for the other Ohio coals. The majority of genera thus far discovered in the Duquesne coal balls (table 1) were also found in Calhoun coal (Mattoon Formation, McLeansboro Group) of Illinois. Floristic similarities in Upper Pennsylvanian coal balls from Ohio and Illinois have been emphasized (Good and Taylor, 1974), but the extensive Duquesne flora provides for a more comprehensive comparison. Histological features of the newly discovered plants indicate that many are specifically equivalent to taxa from Illinois. Others appear to be distinct, but their formal recognition as either new species or additional specimens of currently recognized species awaits detailed examination of the individual taxa.

Most of the plants reported from the Pittsburgh and Redstone coal balls (Good and Taylor, 1974) have been found in the Duquesne material (table 1). The Psaroniaceae is the most common taxon in the Duquesne coal, while members of the Arthrophytina dominate the flora of the Pittsburgh or Redstone coal (Good and Taylor, 1974). At the present time it is not known whether this dissimilarity reflects evolutionary changes during the Pennsylvanian, floristic variations at the respective depositional sites, or perhaps preservational differences in coal balls from the two localities.

The discovery of coal balls in the Duquesne and Ames coals of eastern Ohio significantly increased our knowledge of anatomically preserved Appalachian Basin plants. The extremely rich and well preserved flora of the Duquesne coal balls provides an opportunity to conduct detailed anatomical examinations of numerous taxa, and to make critical comparisons with similar plants from the Eastern Interior and Mid Continental Basins. Additional comparisons of the coal-ball taxa, now known to occur at several stratigraphic levels in Ohio, allow for a fuller understanding of coal-swamp vegetation, and the sequential terrestrial habitations of eastern North America during the late Paleozoic.

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LITERATURE CITED

Cross, A. T. 1967. A coal-ball flora from Pennsylvania. Amer. J. Bot. 54: 652.

Dennis, R. L. 1974. Studies of Paleozoic ferns: *Zygopteris* from the Middle and Late Pennsylvanian of the United States. Palaeontographica 148B: 95–136.

Good, C. W., and T. N. Taylor. 1974. Structurally preserved plants from the Pennsylvanian (Monongahela Series) of southeastern Ohio. Ohio J. Sci. 74: 287–290.

Mamay, S. H. 1957. *Biscalitheca*, a new genus of Pennsylvanian coenopterids, based on its fructification. Amer. J. Bot. 44: 229–239.

Millay, M. A., and D. A. Eggert. 1974. Microgametophyte development in the Paleozoic seed fern family Callistophytaceae. Amer. J. Bot. 61: 1067–1075.

Morgan, J. 1959. The morphology and anatomy of American species of the genus *Psaronius*. Illinois Biol. Monogr. 27: 1–108.

Schopf, J. M. 1961. Coal-ball occurrences in eastern Kentucky. U.S. Geol. Surv. Prof. Paper 424B: 228–230.

Stout, W., R. T. Stull, W. J. McCaughey and D. J. Demorest. 1923. Coal formation clays of Ohio. Ohio Geol. Surv. Bull. 26 (Series 4). 1–588.

Sturgeon, M. T. 1958. The geology and mineral resources of Athens Co., Ohio. Ohio Div. Geol. Surv. Bull. 57: 1–600.